The influence of glacial ice sheets on Atlantic meridional overturning circulation through atmospheric circulation change under glacial climate

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Improving understanding of the dynamics of the glacial Atlantic meridional overturning circulation (AMOC) continues to be an important task for a better understanding of glacial climate. Recently, coupled modeling studies have shown that the existence of the glacial ice sheets intensifies the AMOC. It is very important to understand the cause and implications of this result, which may also help to explain why the AMOC remained vigorous over the last glacial period, as suggested from a recent reconstruction study. Here, a decoupled simulation is conducted to investigate the effect of wind change due to glacial ice sheets on the AMOC and the crucial region where wind modifies the AMOC, which remained elusive in previous studies. First, from atmospheric general circulation model (AGCM) experiments, the effect of glacial ice sheets on the surface wind is evaluated. Second, from ocean general circulation model (OGCM) experiments, the influence of the wind stress change on the AMOC is evaluated by applying only the changes in the surface wind as a boundary condition, while leaving surface heat and freshwater fluxes unchanged. Moreover, several sensitivity experiments are conducted. Using the AGCM, glacial ice sheets are applied individually. Using the OGCM, changes in the wind are applied regionally or at different magnitudes. These experiments clearly demonstrate that glacial ice sheets intensify the AMOC through an increase in the wind stress curl mainly at the North Atlantic mid-latitudes. This intensification is caused by the increased gyre transport and Ekman upwelling of salt, while the change in sea ice transport has an opposite, though minor, effect.